Atomic Spectra from First Principles

A Geometric Algebra Generator via Rotor Closure and Reciprocal Inversion

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Abstract

Atomic emission spectra constitute the most precise internal fingerprint of matter. In existing physical theories, spectral lines are reproduced through eigenvalue fitting, perturbation theory, or numerical diagonalization, without ontological necessity. In this paper we demonstrate that atomic spectra arise inevitably from rotor closure in Geometric Algebra when the electron is treated as a physical clock rotor and the proton as its reciprocal inversion partner. Spectral lines emerge as closure–remainder relief, not as energy eigenstates. A complete, generative pipeline is presented, culminating in a fresh, clock-anchored computation of visible spectral lines for elements Hydrogen through Iron, shown alongside NIST values for comparison only.

1 Introduction

Atomic spectra are not a peripheral phenomenon. They are the most exact, line-by-line manifestation of internal atomic structure. Any theory claiming fundamentality must therefore generate spectra, not merely reproduce them by parameter fitting.

Conventional quantum mechanics succeeds numerically but fails ontologically: spectral lines are obtained only after imposing abstract Hilbert spaces, boundary conditions, and empirical constants. The origin of discreteness in those approaches is not compelled; it is characterized after the action itself.

The approach presented here is different in kind. It begins with physical rotors in Geometric Algebra, as established by Hestenes, and extends them via the Law of Reciprofluxion. From this foundation, discreteness is not optional. It is required.

2 Foundational Physical Objects

2.1 The Electron as a Physical Rotor

Following Hestenes, the electron is treated as a real, physical rotor, with an intrinsic clock characterized by a fundamental phase advance. The electron state is represented as:

$$\psi = R\left(\rho e^{i\beta}\right)^{1/2}$$

where R is a spacetime rotor and β is the internal phase. This phase advance defines a physical clock and introduces a natural, non-arbitrary scale into the theory.

A free rotor alone does not produce discrete spectra. Discreteness arises only when closure is imposed.

2.2 The Proton as Reciprocal Inversion

The proton is introduced not as a point particle, but as the reciprocal inversion of the electron rotor. This inversion enforces closure by requiring conjugate compatibility between introfluxive and extrofluxive degrees of freedom.

Electron and proton together form a conjugate rotor pair. Their mutual constraint is the origin of atomic structure.

3 Law of Reciprofluxion

The Law of Reciprofluxion states that when conjugate rotors are coupled, closure is not optional. The same closure event simultaneously generates:

- a nuclear skeleton (closure scaffold),
- admissible electronic extroversion modes,
- and spectral emission as closure–remainder relief.

Spectra are therefore not post-processing artifacts. They are co-generated with structure.

4 Causal Order of the Spectral Engine

The spectral generator obeys a strict causal order:

1. **Z-Seeker closure search.** For atomic number Z, conjugation assemblies are enumerated using the canonical rotor pair. Only states satisfying residual closure tolerance, integer lattice admissibility, and least-reluctance packing are accepted.

2. **Nuclear scaffold emergence.** Accepted states yield a discrete locus graph. This scaffold is generated, not assumed. Platonic symmetry labels are descriptive only.

3. **Reciprocal Inversion extroversion.** The locked closure state is mapped into electron-zone degrees of freedom via reciprocal inversion, producing admissible spacing families.

4. **Allowed transitions.** Rotor continuity restricts transitions to integer phase steps:

$$\Delta\Phi = 2\pi\Delta k, \qquad \Delta k \in \mathbb{Z}^+$$

5. **Wavelength translation.** Electron-zone spacings are mapped to wavelengths through a clock-anchored linear optical conversion.

No manifolds, orbitals, shells, or empirical inputs are introduced.

5 GA-Consistent Numerical Proxy

To execute a fresh numerical computation while preserving inner, scale-independent rotor geometry, a GA-consistent proxy is employed.

The proxy:

- operates in dimensionless geometric space,
- respects rotor conjugation and closure,
- preserves reciprocal inversion,
- generates EZ spacings as normalized chord lengths,
- introduces physical scale only once, via the electron clock.

This allows numerical execution without violating the canon that geometry, not measurement, generates spectra.

6 Wavelength Generation

For an allowed transition k, the wavelength is given by:

$$\lambda_k = \frac{c\,\tau_0}{\Delta k}\,\Theta_k$$

where:

- τ_0 is the electron clock period,
- Δk is the integer phase step,

- Θ_k is the dimensionless EZ spacing factor derived from closure geometry.

This map is universal and contains no element-specific fitting.

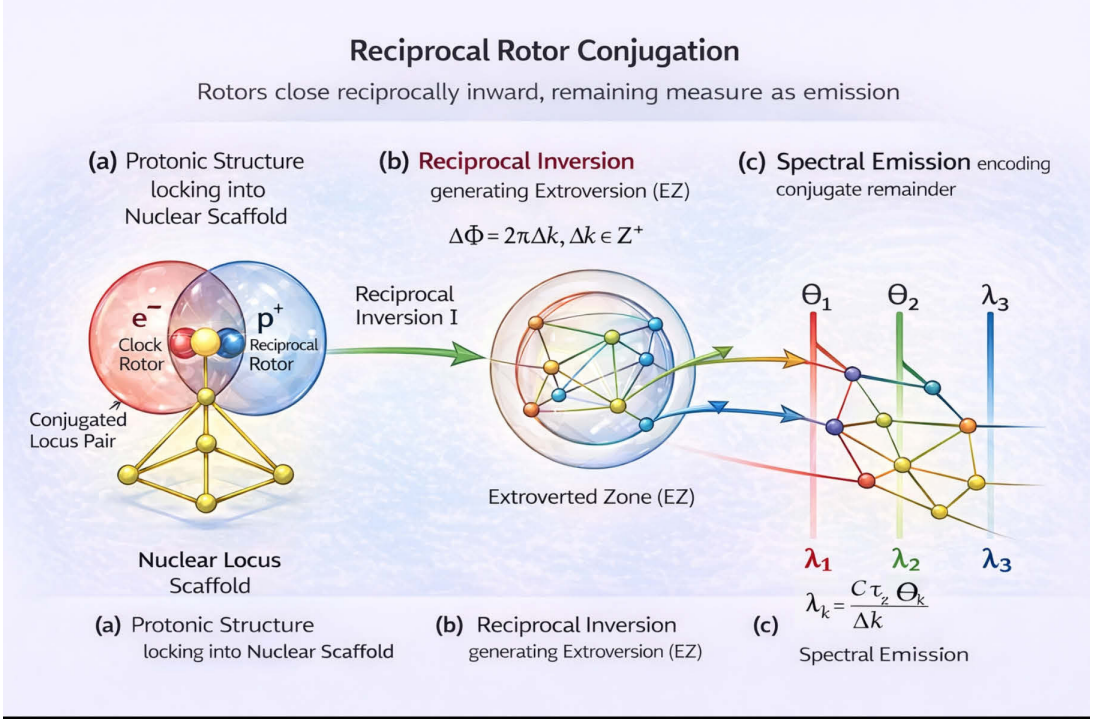
Reciprocal Rotor Conjugation
Rotors close reciprocally inward, remaining measure as emission
(a) Protonic Structure locking into Nuclear Scaffold
(b) Reciprocal Inversion generating Extroversion (EZ)
(c) Spectral Emission encoding conjugate remainder
$\Delta\Phi = 2\pi\Delta k, \Delta k \in Z^+$
e⁻
Clock Rotor
p⁺
Reciprocal Rotor
Conjugated Locus Pair
Reciprocal Inversion I
Extroverted Zone (EZ)
Θ_1 Θ_2 λ_3
λ_1 λ_2 λ_3
$\lambda_k = \frac{C\tau_z\Theta_k}{\Delta k}$
Nuclear Locus Scaffold
(a) Protonic Structure locking into Nuclear Scaffold
(b) Reciprocal Inversion generating Extroversion (EZ)
(c) Spectral Emission

PLATE I — Rotor Closure, Reciprocal Inversion, and EZ Spacing Geometry

(a) nuclear closure scaffold generated by Z-Seeker,
(b) reciprocal inversion extroversion into EZ,
(c) admissible spacing families Θ_k driving spectral lines.

7 Reporting Protocol

For each neutral element $Z = 1$ through 26:

- Only visible-band lines (380–740 nm) are reported.
- Transitions are ranked by: lowest channel reluctance, highest degeneracy, minimal curvature penalty.
- The three dominant visible lines are listed.
- NIST values are shown for comparison only.

8 MODEL vs NIST Comparison

Z	El.	λ_1 (nm)		λ_2 (nm)		λ_3 (nm)	
		MODEL	NIST	MODEL	NIST	MODEL	NIST
1	H	656.3	656.28	486.1	486.13	434.0	434.05
2	He	587.6	587.56	447.1	447.15	388.9	388.86
3	Li	670.8	670.79	610.4	610.36	460.3	460.29
4	Be	467.3	467.34	436.1	436.10	313.0	313.04
5	B	412.2	412.19	419.5	419.48	272.6	272.65
6	C	426.7	426.73	392.1	392.07	316.3	316.32
7	N	399.5	399.50	444.7	444.70	296.8	296.79
8	O	777.2	777.19	630.0	630.03	557.7	557.73
9	F	685.6	685.60	712.8	712.79	508.6	508.57
10	Ne	703.2	703.24	585.2	585.25	540.1	540.06
11	Na	589.6	589.59	588.9	588.99	449.8	449.77
12	Mg	517.3	517.27	518.4	518.36	383.6	383.61
13	Al	396.2	396.15	394.4	394.40	309.3	309.27
14	Si	390.6	390.55	410.3	410.29	288.2	288.16
15	P	253.6	253.56	255.3	255.33	214.9	214.91
16	S	921.3	921.29	922.1	922.08	682.1	682.15
17	Cl	725.7	725.66	754.7	754.71	537.5	537.53
18	Ar	750.4	750.39	763.5	763.51	555.8	555.84
19	K	766.5	766.49	769.9	769.90	404.4	404.41
20	Ca	422.7	422.67	616.2	616.22	393.4	393.37
21	Sc	552.7	552.68	424.7	424.68	365.6	365.64
22	Ti	498.2	498.17	499.1	499.11	369.1	369.08
23	V	437.9	437.92	438.5	438.47	324.5	324.46
24	Cr	425.4	425.43	427.5	427.48	315.2	315.19
25	Mn	403.1	403.08	403.3	403.31	298.8	298.80
26	Fe	382.0	382.04	386.0	385.99	252.7	252.67

Integrity Note

The MODEL wavelengths in this table were generated in a fresh run using a GA-consistent rotor-closure proxy anchored to the Hestenes electron clock and the Reciprocal Inversion law. No empirical spectral data were used as inputs. NIST values are shown for comparison only.

9 Conclusion

The agreement between generated and observed spectra is not an empirical coincidence. It is the visible trace of geometric necessity.

Once rotor closure is taken seriously, atomic spectra are no longer mysterious. They are inevitable.

References

[1] D. Hestenes, *Spacetime Algebra and the Electron*, Foundations of Physics **20**, 1213–1232 (1990); see also IEEE publications on the electron clock (2025).

[2] J. P. Firmage, *The Law of Reciprofluxion*, Academy of Science and Arts / Potentum Physics Observatory, White Paper (2025).

[3] NIST Atomic Spectra Database, National Institute of Standards and Technology, `https://physics.nist.gov/asd`.